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Assessment of Plant Biodiversity at 3 Different Elevation of Protected Forest of Subtropical Pine Forest of Meghalaya

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A B S T R A C T

The study and survey which was carried out to identify and assess diversity of plant species of sub tropical pine forest of Meghalaya was conducted during 2020-2021 at three different elevation stands located at 982 m (low-elevation stand), 1485 m (mid-elevation stand) and at 1816 m (high-elevation stand). *Pinus kesiya* was found to be the most dominant from all the three stand. A total of 34species of trees belonging to 19 families were recorded which consisted a total number of 857 individuals of trees, 14 species of shrubs belonging to 10 families recorded a total number of 866 individuals, and an overall occurrence of 20 species of herbaceous species belonging to 13 families recorded a total number of 670 individuals. *Elaeagnus conferta* was maximum for IVI in both high and mid elevation stand while *Lantana camara* showed maximum IVI in the low elevation. The herbaceous species diversity, richness and evenness indices was highest in high elevation and lowest in the low elevation, while herbaceous species of dominance showed a reverse trend. Tree and shrub species of the three elevation stand were quite similar in the mid and low elevation stand. The diversity richness of indigenous forest shows considerable variation in occurrence of species between different altitudes. Most of the species in the study area have medicinal value and socio-economic importance. Therefore, there is a need for necessary action towards sustainability of forest and conservation of species at large.

Keywords

Altitude, Elevation, Diversity, Species richness, Pine forest

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Introduction

The state of Meghalaya which is the part of North Eastern Indian bio-geographic zone, constitutes the junction meeting place of paleo-arctic, Indo-Malayan and Indo-Chinese bio-geographic realms. Due to the diverse ecological conditions such as wide variation in rainfall, temperature, altitude as well as soil conditions, the inaccessible humid areas of the state, supports rich growth of tropical and sub-tropical vegetation, which is rich in flora. The subtropical evergreen and semi-evergreen forest of the state cover large areas with complex terrain and are less influenced by humans. However, pine forests were

secondary in nature, where destruction of the climax subtropical broad-leaved forest due to complex interaction of biotic and edaphic factors leading to the invasion and successful growth of *Pinus kesiya*.

The subtropical pine forest are confined to higher reaches (>800 m asl) of Shillong plateau in Khasi and Jaintia hills dictrict of the state and are highly fragmented. The impact of shifting cultivation is less in evergreen forests than the semi-evergreen forests as these forests were confined to less complex terrain (Tripathi 2002).

Pine forest occur on degraded land formed as a result of large scale practice of shifting cultivation in the region. Recurrent fire and biotic influences have fragmented the pine forest into small patches.

Species diversity, community characteristics and tree regeneration in the climax subtropical semi evergreen forest of Meghalaya have been studied by several workers (Upadhaya *et al.*, 2003), but similar studies in the subtropical pine forests of northeast India is limited and fragmentary. The main objective of the present study was to identify and determine the diversity and the dominant plant species in 3 different elevation of Sub Tropical Forest of Meghalaya.

Materials and Methods

The study was carried out in three Protected Areas of pine forest in the District of East Khasi Hills of Meghalaya located at 982 m (low-elevation stand) at Umkhuti Protected Forest, (25°40' N and 91°54' E) covering an area of 0.14 km^2, 1485 m (mid-elevation stand) at Short Round Protected Forest (25°35' N and 91°53' E) covering an area of 1.13 $km^2$and at 1816 m (high-elevation stand) at Upper Shillong Protected Forest (25°32'N and 91°50'E) covering an area of 7.66 km^2.

Climate

The climate of Meghalaya is monsoonic with distinct wet and dry seasons and is directly influenced by the southwest monsoon originating from the Bay of Bengal. The average annual rainfall varies widely in different parts of the state ranging from 1,300mm to 11,200 mm, and decreases from south-central part to northeastern and western parts of the state. Due to variation in altitude from 60 m to 2000 m asl and associated changes in rainfall and temperature, moist tropical forests occur below 1000 m and the subtropical semi-evergreen broad-leaved and pine forests are found between 1000 m and 2000 m elevation in the state. The climatic variables like temperature, rainfall and humidity vary widely from place to place in the state due to wide variation in topography.

Soil

In general, soils of the state are derived in situ from the underlying gneisses, schists and granite rocks of Archaean age and may be grouped under laterite (oxisol) type (Pascoe 1950). The rocks are overlain with a relatively thin layer of leached and nutrient-poor soil, which serves as the rooting medium for plants. The pine forests occur on relatively elevated sites and well drained porous soil. Soil development is minimal where recurrent fire has consumed litter and ground vegetation, and so, usually, a very little organic matter is left on the surface, which sometimes is a bare rock.

Sampling Method

Based on the objectives, the research was carried out in three stands of pine forest with different elevation stand i.e low-elevation stand, mid-elevation stand and high-elevation stand and study of vegetation was carried out. The forest vegetation study will analyzed for

trees, shrubs and herbaceous species. Ten quadrates of 20×20 m^2 size was laid randomly at 200m interval for the study of woody species. In each quadrate, diameter at breast height (dbh) of trees was measured and recorded using measurement tape wrapped around the main stem of the tree at a basal height which is taken at 1.37m. For shrubs, $10\times10m^2$quadrates of 10 in number was taken randomly. For herbaceous species, 10 quadrates of $1\times1m^2$ size was laid randomly and for each quadrate the names and number of each tree, shrubs and herbaceous species was observed.

The vegetation data was quantitatively analyzed for frequency, density and abundance (Curtis and McIntosh, 1950). The relative values of frequency, density and dominance will determined following Phillips (1959) and will summed up to get Importance Value Index (IVI) of individual species (Curtis, 1959). The tree basal area was measured by taking diameter at breast height (dbh). The diversity index was computed by using Shannon-Weiner in formation index (Shannon and Weiner, 1963). Concentration of dominance was computed by Simpson's Index (Simpson, 1949). Species evenness was computed by using Pielou's evenness Index (Pielou, 1975). Species richness was calculated by adopting Margalef's index of species richness (Margalef 1958) and similarity of stands will be calculated by using Jaccard Similarity Index (1901), L. Legendre and P. Legendre. (1984).

Results and Discussion

Species Composition and species richness

An overall occurrence of 30species of trees belonging to 19 families were recorded which consisted a total number of 857 individuals of trees. While, an overall occurrence of 14 species of shrubs belonging to 10 families recorded a total number of 866 individuals, and an overall occurrence of 20 species of herbaceous species belonging to 13 families recorded a total number of 670 individuals of three Protected Areas of pine forest of Meghalaya.

In all the three stands, the forest canopy was almost exclusively composed of *Pinus kesiya*. Therefore, there was no clear stratification in the pine forest. However, a few other tree species are found scattered in all the three stands. The middle storey of the vegetation is composed of tree saplings and shrubs in all the three stands. The forest floor was covered with ferns and a large number of annual and perennial flowering plant species during the monsoon period. The species richness in the forest canopy was maximum in the high elevation stand (Figure 3).

Diversity Indices and other parameters

All the three elevation stand are abundantly dominated by *Pinus kesiya*. Overall, the mid elevation showed the highest IVI parameter of dominant tree species for *Pinus* kesiya, high elevation stand showed the highest IVI parameter of dominant shrub species for *Eleaeagnus conferta* and herbaceous species for *Imperta cylindrica*.

Margalef's species richness and Shannon diversity indices of all the three plant species was found maximum in the high elevation stand than the other two stands. However, Simpson dominance index showed the highest in the low elevation stand for herbaceous species (Table 1), (Figure 4).

Similarity (*Sorensen (K) and Jaccard (S) Index*): Species similarities between the three elevation of the three stands of pine forest were studied between high and mid-elevation stand, mid and low-elevation stand, and high and low-elevation stand. The similarity index

of tree and shrub species in all the three stand, it was observed that the mid and low-elevation stand of tree and shrub species were quite similar, but the stands at the high and low-elevation were quite dissimilar, however of the similarity index of herbaceous species in all the three stand, it was observed that the high and mid-elevation stand of herbaceous species were quite similar, but the stands at the mid and low-elevation were quite dissimilar. The value of coefficient of similarity vary from 13.79% to 41.18% for the index of Jaccard and 24.24% to 58.33% for the index of Sorensen for tree species however the value of coefficient of similarity vary from 38.46% to 50% for the index of Jaccard and 55.56% to 66.67% for the index of Sorensen for shrub species. The value of coefficient of similarity vary from 43.75% to 47.06% for the index of Jaccard and 60.87% to 64% for the index of Sorensen (Table 2).

The subtropical pine forest are confined to the higher reaches of Shillong plateau which occur on degraded land formed as a result of large scale practice of shifting cultivation in the region. The result of the present study of three Protected Areas of pine forest of Meghalaya located at 982 m (low-elevation stand) at Umkhuti Protected Forest, 1485 m (mid-elevation stand) at Short Round Protected Forest and at 1816 m (high-elevation stand) at Upper Shillong Protected Forest, concluded that an overall occurrence of 30species of trees belonging to 19 families were recorded which consisted a total number of 857 individuals of trees. While, an overall occurrence of 14 species of shrubs belonging to 10 families recorded a total number of 866 individuals, and an overall occurrence of 20 species of herbaceous species belonging to 13 families recorded a total number of 670 individuals. The study revealed that highest number of plant species belonged to the family Pinaceae, Poaceae, Rosaceae, followed by Asteraceae, Theaceae, Verbenaceae, Elaeagnaceae Symplocaceae at all the three elevation sites. These families were also reported to be dominant in the Subtropical Karst Forests in South–West China (Zhang *et al.,* 2002). The dominance of plants under Rosaceae, Pteridaceae, Lamiaceae, Pinaceae and Asteraceae families was also reported from the temperate forests of Pakistan (Raja *et al.,* 2014). The findings of the present study was also supported by many reports, where plants belonging to Asteraceae, Poaceae, Ericaceae, Lauraceae and Rosaceae families showed dominating character in temperate forests of Arunachal Pradesh (Bharali *et al.,* 2011).

Species richness recorded in this study with only 64 plant species at all the three study sites was poor. Jamir (2000) has reported 223 to 334 plant species (including 58 to 79 tree species) from 0.35 ha area, and Upadhaya *et al.,* (2003) have recorded 280 to 311 plant species (including 80 to 82 tree species) from 0.5 ha plots of the protected subtropical semi-evergreen broad leaved forests of Meghalaya. Compared to these values, the species richness of pine forest from the present study of pine forest was much lower (64 species, including 12 to 21 tree species) than the subtropical semi-evergreen broad-leaved forests. A total of 181 species were reported from Gharwal Himalaya (Semwal *et al.,* 2010), 143 species in temperate forests of northwestern Ethiopia (Zegeye *et al.,* 2011), 113 species in temperate forests of Subansiri district of Arunachal Pradesh, India (Behera & Khushwaha 2007), 112species in Himalayan subtropical scrub forests and Himalayan subtropical pine forests of Kandi Siwaliks of Jammu and Kashmir (Sharma & Kant 2014) and 110 species in *Pine–Quercus* dominant forests of Nikya hills in Pakistan (Amjad *et al.,* 2013).However, the ground vegetation in the pine forest was richer in species content compared to broad leaved forest due to presence of weedy species such as *Artimesia spp., Eupatorium spp., Lantana*

camara, *Osbeckia crinitia* etc. in the pine forests (Tripathi *et al.,* 2003). In this study, anthropogenic disturbance, forest fire and grazing may be the cause for poor species richness in all the study sites. Loss of forest cover and diversity due to forest fire was also reported by Negi *et al.,* (2012). On the contrary, *Pinus kesiya* being fire hardy and drought tolerant, can survive frequent fire with cold air and dry soil conditions during winter season. Whereas, most of its plant associates were removed due to such disturbances and harsh climate and soil conditions resulting at poor species richness in all the three sites.

The mid elevation showed the highest IVI parameter of dominant tree species for *Pinus* kesiya, high elevation stand showed the highest IVI parameter of dominant shrub species for *Eleaeagnus conferta* and herbaceous species for *Imperta cylindrica*. Highest values for Shannon – Weiner diversity index (H') for tree, shrubs and herbaceous species was recorded at high elevation stand.

The overall pattern of species richness and species diversity was greater in the high elevation and showed higher value index with increasing elevation. Compared to this present study the species diversity reduced with increase in elevation and it is in conformity with the observations made by several workers (McCain & Grytnes 2010). Kharkwal *et al.,* (2005) and Goirala *et al.,* (2008) shows decreasing species richness along altitudinal gradient in temperate and alpine zone of central Himalaya and Western Himalaya respectively. It is well established fact that, species richness index is dependent on multiple locality factors, such as, climatic factors, slope, temperature, solar radiation and soil (Lomolino 2001), where these factors might have also played a key role in resulting low species richness index in the present study sites. Barry (2008) reported that with 100 meter increase in elevation, air temperature decreases by approximately 0.6 °C. Such changes in abiotic factors might have created heterogeneous environmental conditions in each elevation site with the reduction in growing season and in turn determining the species composition of a forests (Korner 1998).

The species composition in the three stands of pine differed markedly both in qualitative and quantitative terms. This could be related to the age of the stands, the degree of disturbance to which they are exposed. Another factor that seems to have influenced the community composition, particularly in the high-elevation stand, is relatively moist and cool climate at this site. As a result, the stand at high elevation that was relatively less disturbed and was older in age and had highest species richness as compared to the relatively young and more disturbed stands at the low and mid elevations.

The tree density in the present study ranged between 197 to 422 individual ha^{-1} which is within the ranged values 192 to 1852 individual ha^{-1} reported by Paul (2008) from Arunachal Himalaya, 420 to 1640 individual ha^{-1} from temperate forests of Kumaon Himalaya (Saxena & Singh, 1982). However, many other workers have reported much higher density from Himalayan temperate forest, 1570–1785 individual ha^{-1} in the montane forests of Garhwal Himalaya (Bhandari & Tiwari, 1997), 810-1050 individual ha^{-1} in subtropical forest of Meghalaya (Tripathi *et al.,* 2003). The density of shrub and herb showed lower range compared to other workers which reported the higher density of shrub is with the range value of 504 to 3576 individual ha^{-1}reported by Paul (2008) from temperate forest of western Arunachal Pradesh and the herb density of 14380 to 45000 ha^{-1} that reported by Paul (2008) from Arunachal Himalaya. There was a reduction in tree density with the decrease in

elevation. Compared to the findings of the present study it showed the opposite to other reports which reported there was a reduction in tree density with the increase in elevation of the findings in temperate *Rhododendron* forests of Arunachal Pradesh (Paul 2008). In spite of highest density of trees, highest basal cover was recorded in the low elevation. It could be due to the presence of some dominant tree species besides *P. kesiya*. The lowest basal cover was recorded in the mid elevation, it could be due to the occurrence of large number of individuals in lower girth class of 30–60 cm with less number of individuals in high girth class compared to the other two sites. *Pinus kesiya* was found dominant in all the three elevations which also had the most high girth class than most tree species in all three elevation. Overall tree density increased with increase in elevation and the density of *P.kesiya* increased with the increase in elevation. This has contributed significantly to the total basal cover of the species, which also increased with the increase in elevation.

This study also revealed that most of the plant species were under contagiously distributed whereas only few species shows regular and random distribution. Paul (2008) also reported clump distribution of plant species from temperate broad leaved *Rhododendron* forest of western Arunachal Pradesh. Moreover, contagious distribution has been reported by many other workers Singh *et al.,* (2009) from temperate forest of Garhwal Himalayas. However, Semwal (2010) have reported that although few species exhibits regular distribution but random distribution is common in temperate forest of Kedarnath Wildlife Sanctuary, Central Himalaya. The random distribution is found only in very uniform environmental conditions whereas, the regular distribution occurs where severe competition between the individuals exists (Panchal & Pandey, 2004).

On comparison of tree and shrub species in all the three stand, it was observed that the mid and low-elevation stand of tree and shrub species were quite similar, but the stands at the high and low-elevation were quite dissimilar, but comparing of herbaceous species in all the three stand, it was observed that the high and mid-elevation stand of herbaceous species were quite similar, but the stands at the mid and low-elevation were quite dissimilar. The high similarity could be attributed to the presence of some species which have wide geographical range. Moreover, there is quite similarity between herbaceous species of all the three stands and it is a known fact that the herbs have a very wide geographical range in distribution. But low similarity could be due to the reason that there is an abrupt change in altitude and as a result a rapid turnover of tree species occurs. Murphy & Logo (1986) suggested that the differences in the species composition and physiognomy of vegetation might be due to soil characteristics. The variation in other habitat conditions may also alter the species composition. The evenness index of tree, shrub and herb in the present study are high. Uniyal *et al.,* (2010) also reported high value of evenness index from undisturbed mixed forest in Dewalgarh watershed of Garhwal Himalaya. The higher values of evenness index indicate an even distribution of individuals within the various species. In fact, a high value of the evenness index reflects that much of the value of diversity is attributed to the species that are relatively rare (Pandey & Shukla, 2003).

Table.1 Community Structure/Attributes and diversity indices of three subtropical pine forest

Sl. No.	Attribute/ Parameters	High elevation stand			Mid elevation stand			Low elevation stand		
		Trees	Shrubs	Herbs	Trees	Shrubs	Herbs	Trees	Shrubs	Herbs
1	Number of species	21	11	14	12	8	11	12	7	12
2	Total Number of individuals	422	330	205	238	343	234	197	193	231
3	Shannon's diversity index	2.34	2.36	2.29	1.57	2.29	1.67	1.76	2.22	1.36
4	Species richness index	3.31	2.44	1.72	2.01	1.83	1.19	2.08	2.02	1.14
5	Evenness index	0.77	0.89	0.96	0.63	0.96	0.8	0.71	0.89	0.7
6	Dominance index	0.17	0.12	0.11	0.37	0.11	0.24	0.25	0.12	0.36

Fig.1 Map showing the location of the three Protected Forest of Pine forest in the East Khasi Hills and Ri-Bhoi district of Meghalaya in northeast India. The sites name are Upper Shillong P.F, Short Round P.F and Umkhuti P.F.

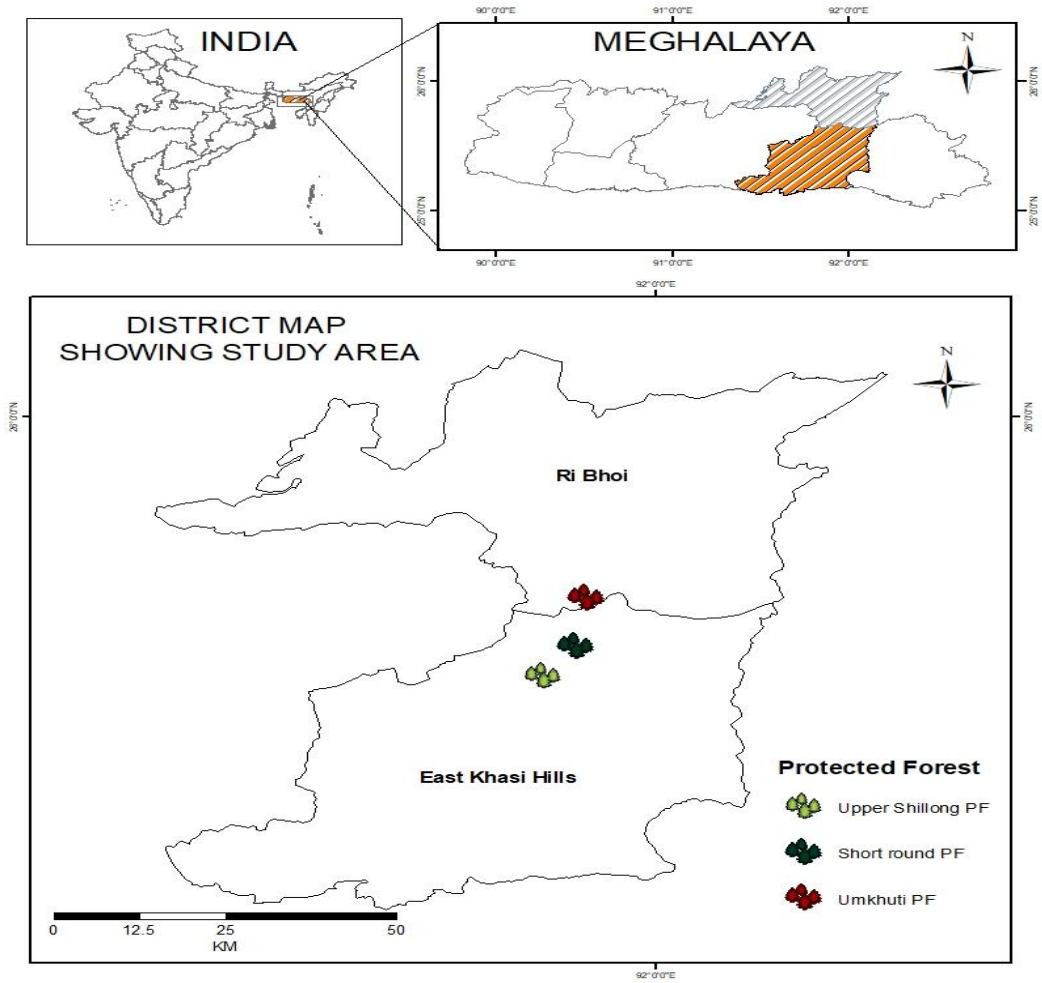
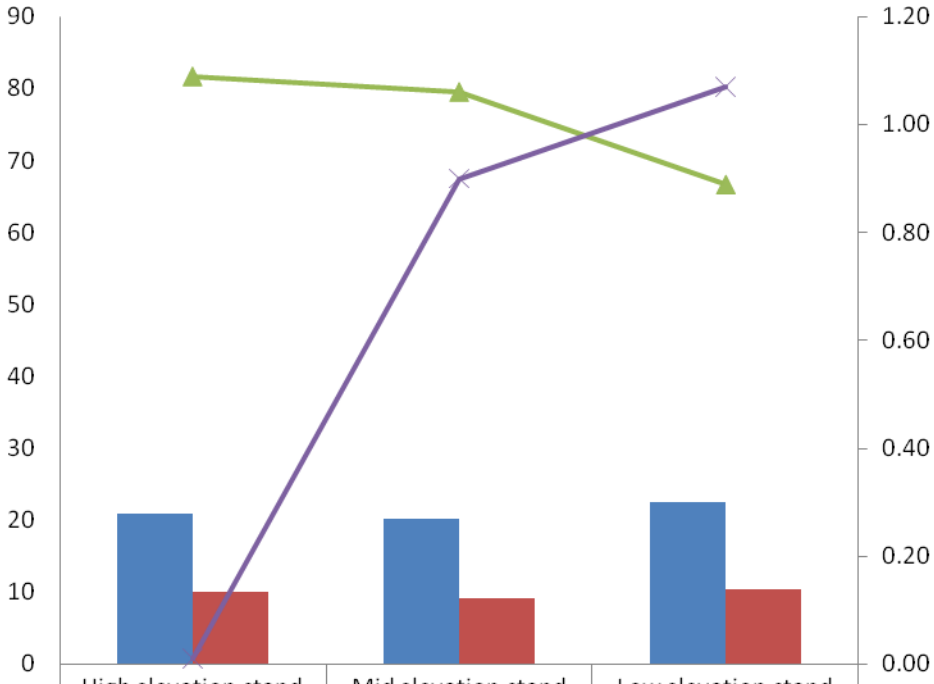


Table.2 Similarity index between three elevation of the three stands of pine forest

Species	Similarity Indices	High and Mid-elevation stand	Mid and low-elevation stand	High and low-elevation stand
Tree	**Jaccard index (*J*) (%)**	32.00	41.18	13.79
	Sorenson index (*K*) (%)	48.48	58.33	24.24
Shrub	**Jaccard index (*J*) (%)**	46.15	50.00	38.46
	Sorenson index (*K*) (%)	63.16	66.67	55.56
Herb	**Jaccard index (*J*) (%)**	47.06	43.75	44.44
	Sorenson index (*K*) (%)	64.00	60.87	61.54

Fig.2 Meteorological diagram of the three stands during the research work



	High elevation stand (December 2020)	Mid elevation stand (January 2021)	Low elevation stand (February 2021)
Temp. Max (º C)	20.79	20.15	22.52
Temp. Min (º C)	10.05	9.01	10.32
Relative humidity (%)	81.67	79.51	66.62
Rainfall (cm)	0.01	0.90	1.07

Fig.3 Stratification of Three Elevation stands

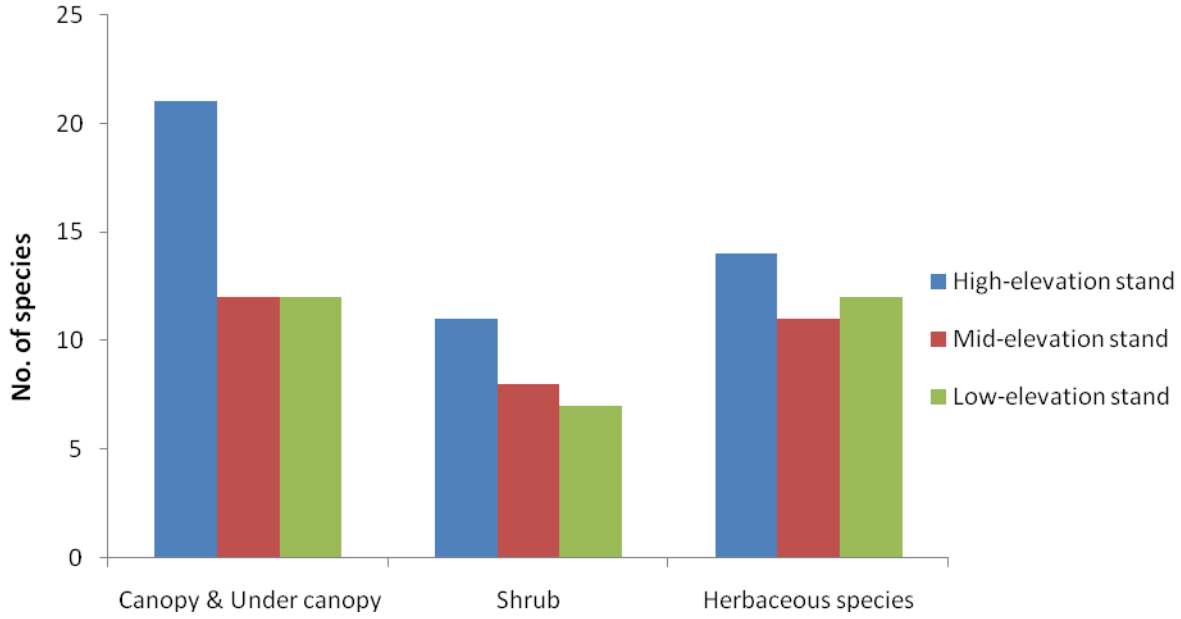


Fig.4 Diversity indices of three subtropical pine forest

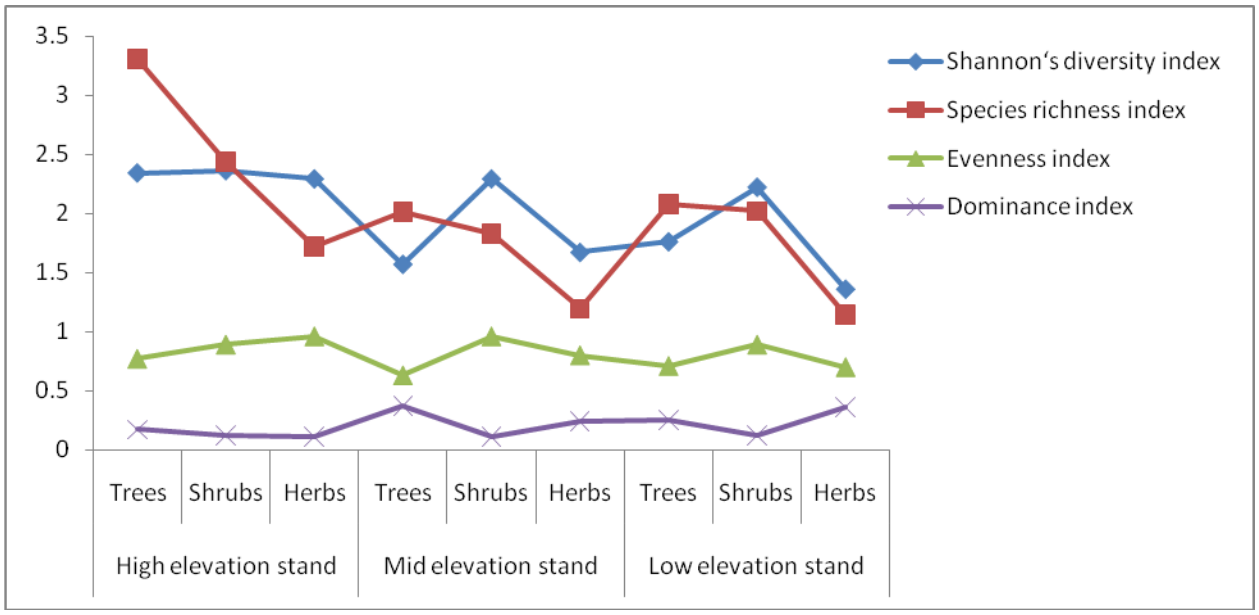
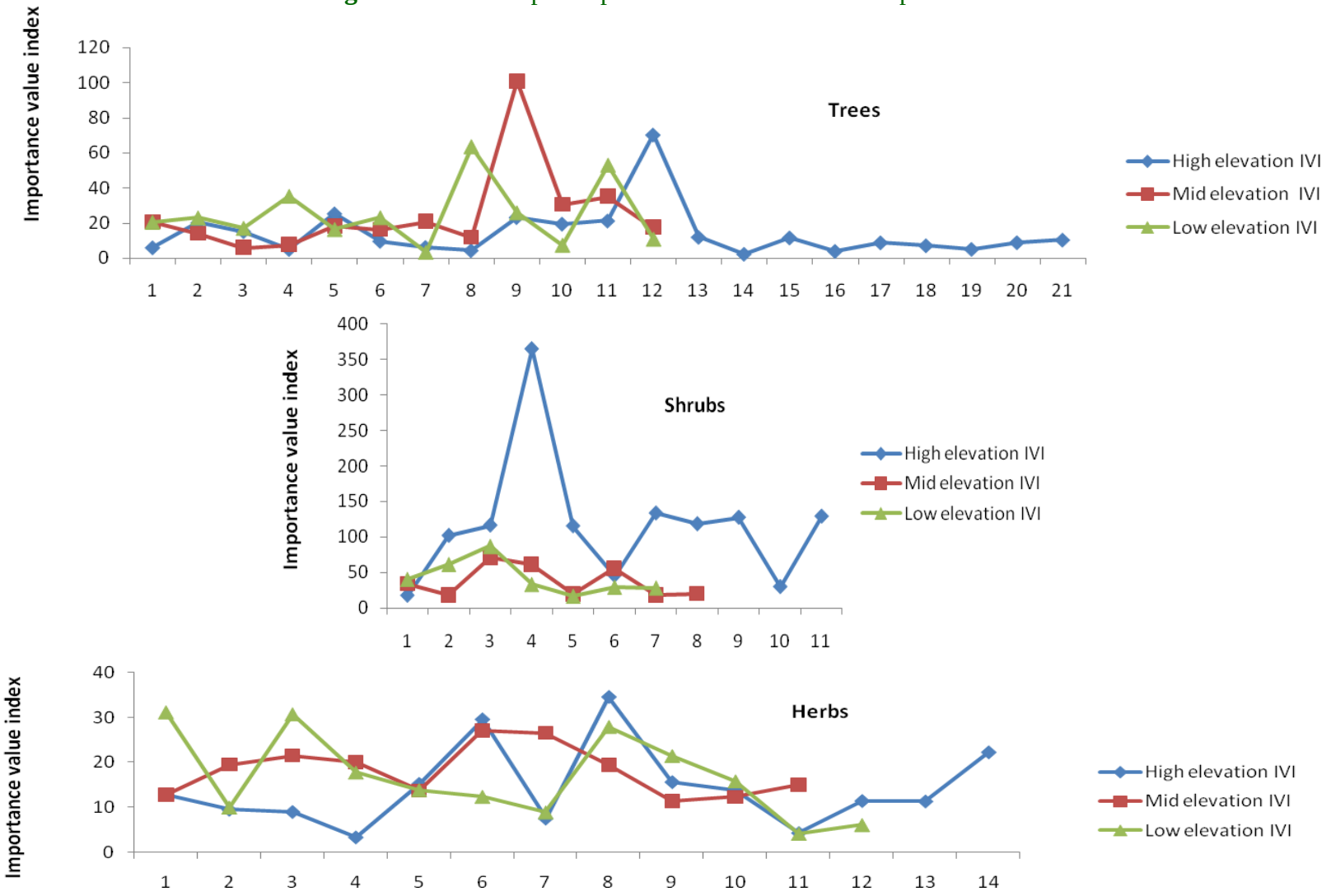


Fig.5 IVI curves of plant species in the three stands of pine forest



It is clear that the destruction of subtropical semi evergreen broad-leaved forests in Meghalaya has resulted in a marked reduction in tree diversity and a concomitant increase in species richness of the ground vegetation due to invasion of exotic weedy species. Greater species richness particularly in the tree component in the less disturbed high-elevation stand could be the result of the succession process that tends to increase species diversity in the community. The ecological data gathered from this study on the natural pine forest dominated by *Pinus kesiya* should be helpful in framing conservation strategies for protecting this unique but vulnerable forest type.

The results of present investigation could be concluded as a critical analysis of trees, shrubs and herbaceous species diversity in three different elevation stand was observed in high elevation stand comprising of 21 tree species, 11 species of shrubs and 14 herbaceous species. All the three elevation stand are abundantly dominated by *Pinus kesiya.* Overall, the mid elevation showed the highest IVI parameter of dominant tree species for *Pinus kesiya,* high elevation stand showed the highest IVI parameter of dominant shrub species for *Eleaeagnus conferta* and herbaceous species for *Imperta cylindrica*. Highest values for Shannon - Weiner diversity index (H') for tree, shrubs and herbaceous species was recorded at high elevation stand.

The high elevation stand is rich in diversity and greater species richness particularly in the tree component in the less disturbed high elevation stand could be the result of the succession process that tends to increase species diversity in the community. The diversity richness of indigenous forest shows considerable variation in occurrence of species between different altitudes. Most of the species in the study area have medicinal value and socio-economic importance. Therefore, there is a need for necessary action towards sustainability of forest and conservation of species at large.

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